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ÚSTAV JAZYKŮ

INSTANT REPLAY TECHNOLOGY AND ITS EFFECT ON GAME SPORTS

TECHNOLOGIE OKAMŽITÉHO PŘEHRÁVÁNÍ A JEJÍ VLIV NA HERNÍ SPORTY

BACHELOR'S THESIS
BAKALÁŘSKÁ PRÁCE

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Bakalářská práce

bakalářský studijní obor **Angličtina v elektrotechnice a informatice**
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Technologie okamžitého přehrávání a její vliv na herní sporty

POKYNY PRO VYPRACOVÁNÍ:

Cílem diplomové práce je nahlížet do literatury o technologických úředních pomůckách v herních sportech, popsat tuto technologii a pak zhodnotit výsledky nejméně dvou nebo tří sportů, které využívají tuto technologii (např. Fotbal, americký fotbal, hokej, baseball atd.). Student vytvoří názor ze svého průzkumu, zda technologie zlepšila herní sporty nebo zhoršila situaci.

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Abstract

The bachelor's thesis describes an instant replay technology and its effect on game sports. It describes instant replay technologies used in football, basketball, American football and its effect on game matches. In the end, it focuses on whether these technologies improved game sports or made things worse.

Key words

Video, referee, VAR, football, basketball, American football, instant, replay, technology

Abstrakt

Bakalářská práce pojednává o technologiích okamžitého přehrávání a jejím vlivu na herní sporty. Popisuje technologie okamžitého přehrávání používané ve fotbale, basketbale, americkém fotbale a jejich vliv na sportovní zápasy. Závěrem pojednává o tom zda tyto technologie zlepšili herní sporty, nebo situaci zhoršili.

Klíčová slova

Video, Rozhodčí, VAR, fotbal, basketball, Americký fotbal, okamžité, přehrávání, technologie

PROHLÁŠENÍ

Prohlašuji, že svoji bakalářskou práci na téma Technologie okamžitého přehrávání a její vliv na herní sporty jsem vypracoval samostatně pod vedením vedoucího bakalářské práce a s použitím odborné literatury a dalších informačních zdrojů, které jsou všechny citovány v práci a uvedeny v seznamu literatury na konci práce.

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1 Introduction

I have chosen Instant replay technologies in game sports as a topic of my bachelor's thesis as I have always been a fan of game sports. I have been actively playing football since I was a child. Therefore, I am very familiar with the game, rules and refereeing both as a fan and as an active player.

No matter the circumstances, referees are always expected to be objective and precise. They must lead the game in the spirit of fair play and let the game flow in maximal fluency. Referees are the ones that cannot afford any mistakes but never get any praise. The pressure on referees in today's game sports is tremendous, but even they are just people that make mistakes. And to eliminate or at least minimize those mistakes, we need instant replay technologies to be introduced and adopted.

Video technology in sport has been the main topic of a lot of discussions over the years. Many believe that video technology made games longer and less natural, while others think that it makes games "cleaner". The main aspect that should determine the outcome of a sports match is a skill and not a referee's mistake, and thus several sports have already included instant replay technologies into their games. This includes hockey, tennis, American football and many others. Decisions became more accurate, and games became "cleaner". Having significantly more cameras around a pitch also increased the experience of spectators behind the television.

The whole thesis is divided into four main chapters. The first chapter deals with the problematics, whether the instant replay technology should or should not be used and outlines its advantages and disadvantages. The second chapter focuses on the history of the instant replay technologies that were used in the past. The third, fourth and fifth chapters are focused on particular sports that I am analyzing in this thesis, namely football, basketball (NBA) and American football (NFL). Furthermore, each of these chapters describes the technology used in the particular game sport, special rules that have been adjusted to the usage of technology and its effect on sports matches. The sixth chapter describes several historical events where the referee made a mistake that changed the history of sports and somewhat helped to the later introduction of instant replays and video referee. Lastly, the empirical part of this thesis is dedicated to the analysis of a survey in the form of the questionnaire.

2 Reasons for demand of instant replay

Sport has always been, to some extent unfair, because the game is controlled by a referee who, like everybody else, can make a mistake. Such mistakes created a demand for something that could correct them. Such technology came not too long ago and was called instant replay. This technology allowed us to view any shot back and evaluate it properly. Nevertheless, even such technology has its drawbacks, several in fact. [21]

The first such disadvantage is certainly the fact that the reviews sometimes require a considerable portion of time and the game is stretched out. Such breaks can turn an exciting match into an endless waiting. Of course, such waiting also affects the players themselves; it allows them to rest, catch a breath and might cause a team that had a power of momentum to cool down.

Another disadvantage of these technologies is the purchase price. Instant replay requires several UHD cameras for maximum efficiency, tracking system installation and much more. Such investments, for example, minor leagues or less wealthy nations cannot afford.

The instant replay also requires the adoption of specific rules that might sometimes be very confusing. An example of such a confusing rule may be the situation from 1st German League, when the home team scored a goal, which was then disallowed, and a penalty given to the guest team instead as the referee could not stop the game and had to wait for a natural stoppage to return to the initial incident. These situations may even cause riots in the auditorium or at least a very unpleasant environment and excessive pressure on the referee.

However, despite all these negatives, instant replay pays off. It allows us to correct wrong decisions that could affect the outcome of the match, increases the objectivity of the match management and ensures a much fairer game. And that is exactly what players, coaches and fans want a fair game without game-changing mistakes made by a referee.

As a small bonus, since instant replay requires the installation of several UHD cameras, the experience of fans behind the TV screens increases as they can watch the match from a large number of shots, angles and slow motion.

3 History of instant replay technologies

Nowadays, technology is allowing us to see instant replays in ultra-slow motion, ultra-high definition and in a vast number of different angles. It would be hard to imagine watching games today without all these features.

The first ever mention of instant replay dates back to 1955 when a producer George Retzlaff tried to provide a replay of a goal during „Hockey Night in Canada ". The device he used was called kinescope, which recorded through a lens focused on a monitor and subsequent record saved on a motion picture film. However, it was a very primitive replay technology as it was unable to display a replay in slow motion and quality of a record was not very good. [2]

In 1961 ABC engineer Bob Trachinger was asked if it would be possible to replay a short videotape in slower motion, mainly for TV and analytical purposes. Trachinger came up with videotape replay machine, which first significant use came in November 25th, 1961 during Boston College – Syracuse football game, when at halftime analyst Paul Christman reviewed the play, made by Boston College's quarterback, in slow motion. In 1967 a company named The Ampex significantly improved this technology with the use of colour disc video machine. These improvements allowed immediate instant slow-motion replay. This new technology was debuted in April 1967 during the World Series of Skiing. [14]

The first significant moment in instant replay history came in 1963 during the US military's Army-Navy football game. When Tony Verna debuted his videotape-based machine which weighed a total of 590 kilograms. Unfortunately, it was introduced only on Army's Rollie Stichweh's touchdown during the fourth period as the replay machine was unable to use earlier in the game due to technical difficulties. [3]

In 1980 Chicago's Interand corporation developed an electronic stylus, that was connected to a special monitor and allowed Tv commentators and analysts to draw over pictures showcased on the monitor. Such technology allowed analysts to showcase and explain things such as zone defences or different plays. This technology had its premiere in January 3rd, 1980 in the NFL playoff game between New York Giants and San Francisco 49ers. [14]

4 Instant replay technologies in football

Instant replay technologies in football have been overlooked for a very long time as FIFA has always wanted to keep football natural as it always has been. However, over the past few years, the demand for these technologies has risen. As the stakes in top-level football got higher, so did the controversies following unclear and confusing football situations. And the need for instant replay technologies has increased. The first such technology (GLT) was introduced at the 2014 FIFA World Cup in Brazil, followed by (VAR) at the 2018 FIFA World Cup in Russia.

4.1 Football associations responsible for the introduction of new technologies

IFAB – (The International Football Association Board) Is made up of representatives of all British football associations (England's Football Association, Scottish Football Association, Football Association of Wales and Irish Football Association) and one representative of FIFA (representing the remaining 209 national unions by four votes). [4]

IFAB is responsible for the rules of the game of football worldwide. The board organises two meetings per year. The first meeting is called the Annual General Meeting (AGM), and the second is the Annual Business Meeting (ABM). The primary purpose of AGM is to discuss and determine possible changes governing the game of football. This year the board has met for the 132nd time, namely in March in Swiss Zurich. Representatives discussed and decided to use VAR in the upcoming 2018 FIFA World Cup in Russia. [4]

FIFA – (Fédération Internationale de Football Association) is an official member body which governs the state of international football. FIFA apart from its main activity, which is organising of competitions (FIFA World Cup, etc.) is focusing on football development as well as taking care of its good reputation.

National football associations are divided into six confederations based on their continent.

• AFC - Asian Football Confederation (Asia and Australia - 47 members)

• CAF – Confederation of African Football (Africa - 56 members)

• CONCACAF – Confederation of North, Central American and Caribbean Association Football (North and Central America, Caribic 41 members)

• CONMEBOL – Confederación Sudamericana de Fútbol (South America - 10 members)

• OFC - Oceania Football Confederation (Oceania - 14 members)

• UEFA – Union of European Football Association (Europe - 55 members) [5]

4.2 Goal-line technology (GLT)

"… but goal-line technology would have made it 2-2 today and given us the confidence and belief that we could beat the Germans." (England player Steven Gerrard following the Germany v. England match, 27 June 2010, Daily Telegraph) [6]

GLT is an electronic system that immediately informs the referee if the goal has been scored, i.e. that the ball has fully crossed the goal line. This system of monitoring the goal line with the use of cameras or computer simulation was newly introduced at the 2014 FIFA World Cup in Brazil as FIFA decided to avoid controversy when it comes to the ball crossing the goal line. The very first GLT system was made in Germany and was called "GoalControle 14". GoalControle 14 was equipped with 14 high-speed cameras placed all around the pitch. Each of the posts was covered by seven cameras that were constantly tracking the ball and drawing it into the 3D model. Once the ball crossed the goal line, an indication was received via the referee's watch, by vibration and visual signal. Installation and testing of this system were successful in all 68 tests across all 12 Brazilian stadiums hosting the 2014 FIFA World Cup. [6]

In 2016 FIFA together with an executive committee, UEFA approved the inclusion of the GLT system named "Hawk-eye" into verified systems of the goal line. Hawkeye was running on a

similar principle as GoalControle 14 with seven high-speed cameras on each of the posts. The advantage of this system is apart from correct goal decisions the fact that AAR (Additional assistant referee) can focus more on the play in the penalty area. [6]

"I think it is a fair solution. During the 2010 World Cup, I was there when England scored a goal, and the referee did not recognise it. The referee will no longer harbour any doubts – in or out." (Germany player Manuel Neuer, FIFA Ballon d'Or 2014 press conference, 12 January 2015) [6]

4.3 Video assistant referee (VAR)

The VAR stands for video assistant referee. It usually consists of three people situated in a video operation room. Such team consists of video assistant referee, his assistant and video replay operator. Their job is to watch the game and examine certain situations and to communicate with the main referee on the field. The video operation room is usually equipped with several monitors that are connected to all cameras monitoring the area. Therefore, they have access to several different angles and should be able to evaluate all incidents correctly.

The main idea of the video assistant referee is not to make every decision correctly, but to precisely and accurately evaluate the critical situations that may affect the final score. The video assistant referee does not make final decisions. He can only support and advice the main referee. Nevertheless, the final decision is always up to the main referee. The usage of VAR is specified by IFAB and may be used only following these situations:

- goals
- penalty decisions
- all red cards incidents
- all cases of mistaken identity

4.3.1 Testing of video assistant referee in the world

System VAR already functions in more than 40 leagues around the world in various forms. The full extent of VAR features in German Bundesliga, Italian Seria A, Portuguese Primera Liga, Korean K League 1 and American MLS. VAR is used for highlighted games in Czech, Netherlands, Belgium, and Poland. Much more time and many more changes are needed until VAR becomes an essential part of Football. Primarily because of its high acquiring costs and an additional cost of training courses for referees.

4.3.2 Principles for the use of video assistant referee

VAR access is only possible based on a specified protocol (goals, penalties, red cards, player identification) and when the main referee on the field makes a decision. The video assistant enters the match only when it is absolutely certain that the technique is justified. In case of doubt, he leaves the decision to the main referee and does not interfere with the match.

More important is the correctness of the verdict, not the speed. FIFA, therefore, urges that no pressure can be put on the speed of decision.

Actual referees listed on the list of professional competitions or recent referees with at least 2-year experience in professional leagues may become video assistants. Only after the completion of the VAR training course, they are eligible to become video assistants. Each match is monitored by two video assistants. One is examining the incident, while the other is observing the continuation of the game.

The video assistant watches the match in a video operation room usually located inside the stadium. The referees on the field are connected via a communication device. If he is sure that the main referee is making a mistake, he will give him a signal that he is reviewing the situation. Subsequently, he must provide him with comprehensive information about the offence and with the proposed penalty. The main referee then interrupts the game and either bring the verdict straight or watches the replay on the monitor. He can reject the video-game proposal and stand behind his original decision. The final verdict is always the main referee.

VAR can be used in offline and online modes. There is no contact between VAR and referee in off-line mode, so there is no impact on the game. Off-line matches are mainly used to practice. In "online" matches, VARs and referees are in contact, and instant replays can be used for all selected situations. If appropriate and given by the protocol, the referee may change the original decision directly by using the on-field recordings or indirectly ("VAR only" judgments).

The silent check is a term for communication between the main referee and video assistant referee who reassures him of a correct decision. Does not change the decision, but in the case of a penalty kick, goal or red card reassures him of the correct decision. Communication between the referee and video assistant referee is recorded and then evaluated.

Monitor for the main referee is placed behind the advertising panels. The monitor is placed on the visible place close to the pitch to make a review as fast as possible. For maximum transparency, the referee should not leave the area to make it clear that no one has influenced him. He stands alone at the video monitor.

All goal situations are examined by one of the video assistants, i.e. whether the ball fully crossed the line, whether the goal was scored from the offside position of the attacking team, whether the attacking team committed a foul, handball or whether the ball was out of play.

In the case of penalty kicks, a video assistant examines the foul incident whether the incident happened in or outside the penalty area. Whether the attacking team committed a foul or an offside position. If the main referee incorrectly does not call the foul, but the foul was committed out of the penalty area, a video assistant does not enter the game.

The video assistant comes into play when

the main referee and the assistants did not see the foul that happened out of play

the main referee calls the foul but does not give a red card that should have been awarded

the main referee does not call the foul, which should have been awarded a red card

The video assistant signals that he is examining the situation and the main referee interrupts the game in a neutral zone, not in a scoring chance. If a goal is scored, but the player should have been sent off before the goal, the goal will not be disallowed, and the referee will return to the first offence.

The yellow card is not part of the protocol created by the IFAB, so it is not subject to a video review.

The rules of football do not allow referees to change their decisions if the game has started again, and this also applies to the use of VAR. The only exceptions are red card offences, including violent behaviour, spitting, biting, and an extremely offensive gesture that can be solved at any time due to its severity.

If the referee needs to delay a restart of the game to communicate with the video assistant referee, because of a possible incident review, he signalises this by pointing to his ear. Therefore, this is not considered as official VAR review. If the referee decides to review the incident, he signalises this by making a shape of television with his both hands. After the review, he makes the same signal again before he reveals the final decision.

The referee signals the "check" and "review" with his arms. "Check" - if the referee needs to postpone the continuation of the game because the VAR is to "check", he holds his finger on one ear and pulls the other arm. "Review" - the Referee shows that the incident will be reviewed by signalling the screen with both hands. At the end of the review process, the Referee will make the same signal again before communicating the "final" decision.

The grey zone is a term for ambiguous situations. FIFA strives to minimize the so-called grey zone. The point is to unite decisions and view of the judges around the world. However, due to the human factor, it is still not possible even for the VAR.

FIFA is also considering the possibility of showing instant replays to viewers at the stadium. So far, they are deciding whether to show every replay (USA), show only selected replays or none at all. This is due to the lack of fan-maturity in some countries to respect the video assistant's verdict in any situation, which can lead to riots in the auditorium and excessive pressure on the referee.

In the event of a video technique failure, the match continues. The main referee is informed about this, and then the 4th referee informs the coaches. [7]

4.3.3 Video assistant referee in 2018 FIFA World Cup in Russia

Based on mostly positive experience, FIFA officially decided to include video assistant referee in FIFA 2018 World Cup in Russia that took place this summer.

FIFA decided that VAR team will be available to all 64 games on the 2018 FIFA World Cup. VAR team consists of VAR (Video assistant referee), four replay operators and three AVARs (Assistant video assistant referee) all these assistants were strictly chosen and belong among the best referees around the world with the vast amount of experience from top-level professional football. Thirteen of the best and most experienced referees were chosen to be functioning solely as VARs (see Figure 1) [8]

VAR team had its centre in Moscow. They had access to camera feed on all 12 stadiums. All 33 cameras were available to the VAR team including eight super slow-motion cameras, four ultra-slow-motion cameras, and two offside cameras. [8]

Figure 1: VAR operation room in Moscow [8]

As mentioned above, the operating room consists of four replay operators, video assistant referee (VAR) and three assistant video assistant referees (AVAR). Replay operators ensure the best possible angles. VAR watches the main camera and coordinates the entire team or talks to the main referee on the field. AVAR1 also monitors the main camera, AVAR2 monitors offside situations and AVAR3 monitors the TV program feed [8]

According to data released by FIFA, a total of 455 incidents were checked by a video assistant during the World Championships, but only 20 of them were whistled, meaning that the interference came every 3.2 games. Each interference lasted an average of 55.6 seconds if the referee decided to check the incident on his own delays were somewhat longer and averaged 86.5 seconds. As for the correctness of these interferences, FIFA prides itself that a total of 99.35% match changing decisions have been called correctly. [20]

5 Instant replay technologies in basketball (NBA)

Instant replay in NBA was initially used mainly to review "buzzer-beaters" (last second shots). The first ever use of this technology came in the play-off of season 2002-2003. Specifically, in the 4th match of western conference final between Los Angeles Lakers and Sacramento Kings when forward of Los Angeles Lakers Samari Walker scored a three-point shot from the middle of the pitch at the end of the second quarter. However, the replay showed that as the game clock run out the ball was still in his hands. Therefore, the field goal had been disallowed. The very first significant change to using instant replay came before the 2007-2008 season. NBA decided to extend the use of instant replay to the determining of players involved in brawls or flagrant fouls and to their subsequent punishment or ejection. Another extension came before season 2008-2009 as NBA decided to allow reviews of determining, whether a scored field-goal was in a two-point territory or a three-point territory or eventually to determine the correct number of free throws awarded after a shooting foul. It could also be used to determine a remaining time in cases when the game clock was broken or started incorrectly. [2]

5.1 NBA replay centre

NBA replay centre is situated in Secaucus, New Jersey. It was introduced before the start of season 2014-2015. The centre is equipped with 94 HD monitors and is connected to all 29 NBA arenas with access to all their camera footage. There is a total of 20 workstations in the centre. [10]

The introduction of the NBA replay centre was mostly seen as a positive step forward.

The most significant success was to reduce the average time of review to just 42.1 seconds per replay, which was more than 50% less than the average of the previous season (see Table 1). [9]

In the premiere season, the operators have reviewed more than 31000 hours of replays. NBA also decided to allow the public to look through the same replays that were shown to referees together with a full explanation of the reviewed incident and decision made. [11]

Trigger	Frequency	Overall Representation	Avg. Review Time (seconds)
2pt/3pt	623	29%	32.4
End of Period Made FG	482	22%	22.5
Foul-Flagrant Criteria	265	12%	57.9
Out of Bounds	212	10%	75.6
Foul-Clear Path Criteria	205	9%	47.8
Shot Clock Violation	135	6%	37.2
Off-Ball Foul Timing	55	3%	53.2
Last Second Foul	44	2%	44
Player Altercation	44	2%	84.3
Correct FT Shooter	32	1%	32.8
Clock Malfunction	20	1%	58.2
Goaltending/Basket Interference	19	1%	62.3
Shot Clock Reset	18	1%	79
Restricted Area	8	0%	57
Six Players on the court	0	0%	
Total	2162		

Table 1: 2014-15 Regular Season Breakdown Trigger and Average Chart [10]

Every game is monitored by one replay operator in 1 of 20 workstations. The operator watches the match and tags every play that could be potentially reviewable. These tagged plays are archived for the rest of the game and are available for possible review by the referee. If such a situation happens and the referee asks for a replay, replay manager comes into the workstation and takes over the situation. The operator then proceeds to find different angles of the incident. There is a monitor in every arena located right by the sideline available to the referee. It includes a headset for communication with the replay manager. [12]

5.2 Situations reviewable by instant replay technology (NBA)

Review of Last Second Field Goals

The referees review if the ball left shooter's hands before the game clock run out.

If the replay confirms that the shot was made in time, the referee might also review:

1) Whether the shot was taken in the 2-point or 3-point territory
2) Whether the shooter or ball stepped out of bounds before the shot was taken, the field goal would then be disallowed

If the replay confirms that the shot was not made in time, to correctly determine the remaining game time or shot clock time, the referee might also review:

1) Whether the player or ball stepped out of bounds before the field goal attempt
2) Whether the ball left shooter's hands before or after the 24-second shot clock run out
3) 8-second backcourt violation
4) Unsportsmanlike behaviour between other players [13]

Review of Last Second Fouls

The Referees review every called foul with no time remaining on the game clock. This is ordered by the rules, and the referees must review the incident regardless of the game score. The referee is looking to confirm whether the foul occurred before or after the game clock run out. The referee might also review:

1) Whether the shot was taken in the 2-point or 3-point territory before a shooting foul
2) Whether the foul occurred before the 24-second shot clock run out
3) Whether the player or ball stepped out of bounds before the foul occurred
4) 8-second backcourt violation
5) Unsportsmanlike behaviour between other players [13]

Review of Flagrant Fouls

The referees are required to review every foul suspected of being a flagrant foul (excessive harming foul). The referee is trying to determine:

1) Whether the foul occurred from a natural basketball movement
2) Whether the excessive foul was intentional
3) Potential injury following the contact [13]

Review of Player Altercations

Any situation, including players involved in a brawl or physical interactions that are not part of the natural basketball game. [13]

Review of 2-Point, 3-Point Field Goal Attempts or Fouls

The referee might use instant replay to find out whether the shot was taken in the 2-point or 3-point territory. The referee does not stop the game and reviews the play at the next natural game stoppage, period brake or timeout. [10]

Review of Clock Malfunctions

In case of damaged clock, the referee may use instant replay to determine the remaining game time or shot clock time. [13]

Review of Shot-Clock Violations

The referee might review whether the ball left shooter's hands before or after the 24-second shot clock run out. The referee might also review:

1) Whether the shot was taken in the 2-point or 3-point territory
2) Whether the player or ball stepped out of bounds before the shot clock violation
3) Unsportsmanlike behaviour between other players [13]

The referees are required to review every out of bounds incident that occurred in the remaining two minutes of the fourth period or the overtime if they are not certain who touched the ball last before the ball moving out of bounds. [13]

Review of Correct Free Throw Shooter

The referee needs to correctly identify a fouled player that will be shooting free throws.

The referee might also review:

1) Whether the shot was taken in the 2-point or 3-point territory before the shooting foul occurred
2) Whether the foul occurred before the 24-second shot clock run out.
3) Whether the player or ball stepped out of bounds before the foul occurred
4) 8-second backcourt violation
5) Unsportsmanlike behaviour between other players

Restricted Area Block and Charge Review

The purpose is review whether the defender was in a legal defending position and if he was in a restricted area. [13]

Review of 24-Second Shot Clock Reset

Instant replay may be used to identify whether the ball hit the rim following the shot attempt.

1) If the ball hit the rim and the attacking team secured a rebound, they get the ball back.
2) If the ball did not hit the rim and the attacking team secured a rebound, they lose possession.

The referee might also review:

1) Whether the ball left shooter's hands before or after the 24-second shot clock run out
2) Whether the player or ball stepped out of bounds before the field goal attempt
3) 8-second backcourt violation
4) Unsportsmanlike behaviour between other players [13]

6 Instant replay technologies in American football (NFL)

The initial experiments with instant replay in NFL date back to 1976, when the director of officiating Art McNally wanted to find out how long would a possible video review delay a game. Equipped with just a stopwatch and access to video camera footage he watched a Monday Night Football game between Dallas Cowboys and Buffalo Bills. He saw a missed call that could have been corrected with instant replay review within a small amount of time. [15]

The first actual test with instant replay technology came two years later, during several preseason games. Unfortunately, the system's performance was insufficient, too expensive to install at every stadium and the number of cameras used for broadcast at the time was not enough for optimal functionality of instant replay technology. Given the unconvincing results, lengthy reviews and total expenses the NFL decided not to use instant replays during the regular season and shelved the project until the 1980s. [15]

The NFL resumed testing of instant replays during the 1985 preseason games. This time with an improved system and a bigger number of cameras. Due to the significant improvements and adequate performance, the league representatives and club owners decided to use instant replay technology in the upcoming 1986 season. [15]

Reviewable play during its first few seasons included possession plays, play governed by the goal lines, boundary lines, line of scrimmage, line to gain and easily detectable violations such as too many men on the field and did not include coaches' challenge.

As we can see in tab.2 instant replay's first seasons averaged 2.2 reviews per game, and only around 12.6% of them end in a call reversal (see Table 2).

Year	Games	Plays Reviewed	Reversals
1986	224	374 (1.6 per game)	38 (10%)
1987	210	490 (2.3 per game)	57 (11.6%)
1988	224	537 (2.3 per game)	53 (9.8%)
1989	224	492 (2.1 per game)	65 (13%)
1990	224	504 (2.2 per game)	73 (14.4%)
1991	224	570 (2.5 per game)	90 (15.7%)
1986–1991	**1,330**	**2,967 (2.2 per game)**	**376 (12.6%)**

Table 2: 1986-91 Seasons Breakdown Trigger and Average Chart [15]

After a six-year-long trial period, 17 out of 28 club owners voted against renewing the instant replay system for the upcoming seasons. According to club owners, the delays were still too long, and the number of call reversals was insufficient. [15]

The NFL once again resumed testing of instant replays during the 1996 preseason games. This time with adjusted rules as coaches' challenge was introduced and with much-improved technology. Touch-screen monitors replaced VCRs and small monitors. Instant replay with these new changes found its success immediately. In its first season back in operation in 1999, it more than doubled the previous average of call reversals from 12.6% to 29% (see Table 3). After several successful years in operation, instant replay became a permanent fixture of the league as 30 out of 32 club owners agreed. [15]

Year	Games	Total Plays Reviewed	Avg. Reviews/ Game	Total Plays Reversed	Percentage of plays reversed	Avg. Delay/ Review
1999	248	195	0.8	57	29%	2:54
2000	248	247	1.0	84	34%	3:05
2001	248	258	1.0	89	34%	3:04
2002	256	294	1.1	94	32%	3:01
2003	256	255	1.0	66	26%	3:13
2004	256	283	1.1	88	31%	3:18
2005	256	295	1.2	92	31%	3:16
2006	256	311	1.2	107	34%	2:37
2007	256	327	1.3	122	37%	2:38
2008	256	315	1.2	117	37%	2:40
2009	256	328	1.3	126	38%	2:39
2010	256	361	1.4	133	37%	2:42
2011	256	390	1.5	172	44%	2:30
2012	256	435	1.7	170	39%	2:33
2013	256	423	1.7	185	44%	2:25
2014	256	439	1.7	151	34%	2:13
2015	256	415	1.6	176	42%	2:16
2016	256	345	1.3	149	43%	2:25
1999–2016	**4,584**	**5,916**	**1.3**	**2,178**	**37%**	**2:45**

Table 3: 1999-2016 Seasons Breakdown Trigger and Average Chart [15]

6.1 NFL replay centre

NFL Replay Center is located in Manhattan, New York. This centre was introduced before the start of the 2014 season. The centre is named after a longtime director of officiating of the NFL. The centre is equipped with a total of 90 high-end monitors that are connected to each stadium from the National Football League. The aim of this centre was to reduce the impact of the review on the length of the game. (tab.3) We can see that this has been done only to a certain extent, and the length of the review has been reduced by just a few seconds in its 2014 premiere. Another goal of this centre was to create a cooperation between the referee on the field and Senior Officiating Staff in Art McNally GameDay Central (AMGC) and to minimize the inconsistency of replay reviews. A slight change in this collaboration took place in 2017 when the NFL decided that one of the Senior Officers in Art McNally's GameDay Central will always have a final decision. [16]

Like the NBA Replay Center, each national football league match is observed by a video operator that has four monitors available. The first monitor shows what the viewers are seeing on the TV with 6-7 seconds ahead. The second monitor displays a video that is being shown to the referee on the field. On the third monitor, there are shots from different cameras and different angles, the shot that the Senior officiating staff select projects on the fourth monitor. [16]

When analyzing the situation, Senior Officiating Staff and the Referee on the field communicate with each other using a wireless headset.

6.2 Situations reviewable by instant replay technology (NFL)

Reviewable plays

1) Possession plays
2) Plays governed by the goal line, boundary lines, line of scrimmage, line to gain
3) Plays involving touching the ground or touching the ball
4) Number of players on the field
5) Game clock
6) Spot of a foul
7) Penalty enforcement
8) Player disqualifications

Coaches' challenge

At the start of each game, the team is given two challenges that will trigger an instant replay review. Such review is initiated by the head coach by throwing a red flag into the field of play, before the next snap or kick. Each challenge requires the use of a team timeout. If a challenge is successful, a team challenge is restored. The team may be awarded a third challenge, but only under the circumstance that the previous two challenges were both successful, but a fourth challenge is not allowed under no circumstances. A team may challenge any of the reviewable situations from the group above except 1) after consuming all of team timeouts or challenges

2) after causing a foul play that delays the next snap

3) in overtime

4) after two – minute warning of each half

When a replay review is initiated, one of the senior officiating staff in Art McNally GameDay Central in New York will examine the incident. At the same time, one of two replay technicians that are located at each 20-yard line will bring the Microsoft instant replay tablet to the referee. After the final decision is made, the referee announces the decision to the entire stadium. [16]

7 Refereeing mistakes that influenced sports history

In the history of sports, there have been thousands of matches in which the course of action or even the outcome of the match has been influenced by a negative human factor. Here I present three games in which the human factor greatly influenced the game and to some extent changed the history of the sport and partly contributed to the later introduction of instant replay.

7.1 WC 1966 England – West Germany (Football)

World Championship 1966 England - Germany ("West Germany") Perhaps the most controversial goal of history, which has decided that England will become the world football champion for the first time, was scored 52 years ago. A certain distrust about the triumph of England at the 1966 World Championship remains to this day. English victory was decided in the 8th minute of overtime by Geoff Hurst's goal.

The football match took place on the field at Wembley, London. It was uncertain whether the ball shot by Englishman Geoff Hurst, which bounced down the crossbar and back into the field, crossed the goal line. At first, it seemed that the referee would not allow the goal. However, the English began to protest, and because the main referee Dienst was not sure of the ball's bounce spot, he asked his Soviet assistant Tofiq Bahramov for opinion. Bahramov was of the opinion that the ball had crossed the goal line with all its volume, so at the instigation of the assistant referee, the main referee acknowledged the goal. Nowadays, modern technology would immediately determine whether the ball crossed the goal line of West Germany after Hurst's shots but on July 30, 1966, only the judge's eyes were deciding.

Goalscorer Hurst himself commented on the situation for the FIFA international program in the sense that he did not see exactly through the goalkeeper and also hit the ball in the fall, but the goal certainly fell. His faith has allegedly remained to this day. [18]

7.2 WC 1986 England – Argentina (Football)

God's hand. In the quarter-finals of the 1986 World Cup in Mexico, teams of England and Argentina were facing each other.

The football match took place on the field at Estadio Azteca, Mexico City. Just three minutes were enough for the legendary Argentinean footballer Diego Maradona to make people write and speak about the match to this day. During these 3 minutes, Maradona scored two goals and basically sealed the outcome of the match. The first scored goal can be described as one of the most controversial, the other as one of the most beautiful goals of all time. During the first goal he used an unauthorized trick with a prolonged hand of "God", in the latter he changed the player's opponent, including the goalkeeper, into a slalom pole. In the 51st minute during the first goal, the star football player reached the tip of the attack, escaped the offside trap of his opponent's team and succeeded in the aerial duel with goalie Shilton, despite being 20 centimetres shorter. Perhaps all the players, viewers and fans of the TV screens saw that the Argentinian captain hit the ball with his hand. The only ones who did not notice the intervention were the referees.

The English, of course, ardently protested against the regularity of Maradona's goal, but Tunisian referee Ali Bin Nasir acknowledged the goal incomprehensibly. *"If it was a hand, it was God's hand."* Maradona claimed after the match, but later admitted he had helped in an unauthorized manner *"I was waiting for my teammates to embrace me, and no one came… I told them: 'Come hug me, or the referee isn't going to allow it"*. Not a very good example of fair play for youth of all future generations. Ironically, "The golden boy Diego" was declared the best player of the tournament. Nowadays, it would take just a couple seconds and the main referee Ali Bin Nasir would receive a confirmation from his video assistant that Diego Maradona indeed hit the ball with his hand and a goal would be disallowed. [17]

7.3 1988 Seahawks – Jets (NFL)

With less than 30 seconds left on the game clock, on a fourth-down and with 5-yards to get the New York Jets trailed the Seattle Seahawks 31-26 and only a touchdown could win the game for them. The New York Jets quarterback Vinny Testaverde tried his luck and rushed towards the end zone. However, he was stopped by Seattle's defence just centimetres away from the end zone. Nevertheless, the main referee decided that quarterback Vinny Tasteverde got the ball behind the end-zone and announced a touchdown for the New York Jets. Television viewers had the opportunity to see this play many times, it was clear from these shots that Tasteverde did not get behind the end-zone, but all these shots were pointless as the instant replay was not allowed for the 1998 season.

This win kept New York Jets tied for the first place, but heavily hurt the chances of Seattle Seahawks of making into the playoffs. Seahawks end up just one game short of playoffs, and New England Patriots advanced to the playoffs instead of them.

This game was one of the primary triggers that restored the talks about instant replay technologies. And the very next year, the NFL voted to re-institute instant replay after a seven-year absence (see Figure 2). [19]

8 Research

The aim of the empirical part of this thesis is to determine whether instant replay technology has improved game sports or made things worse. To achieve this goal, I decided to create a survey in the form of a questionnaire.

The questionnaire was composed of a total of 17 questions. These questions were designed for potential respondents with experience and background knowledge of sports. However, all the questions will be explained in the later chapter for a better understanding.

A total of 63 anonymous participants contributed to this survey with their answers. This survey included both women and men of different ages ranging from 15 years old to 26 years and older.

I used google documents to create a questionnaire, mainly for easy manipulation, the possibility of online data collection and simple and efficient sharing without the need to print questionnaires and hand them out in person.

In the first part of the questionnaire, participants are asked a few general questions about their gender and age. The second part of the questionnaire investigates whether the respondents are fans of sports and, if so, which sports they actively follow. The next parts deal with the rules that instant replay technology has adopted, the main pros and cons of these technologies, whether these technologies are beneficial to sports and their future.

8.1 Questionnaire results

Overall, this questionnaire was completed by 63 anonymous respondents in order to identify specific information about instant replay and whether they are beneficial to sports. The questionnaire was prepared beforehand with the knowledge that it will be shared in places gathering sports fans. All data collected were used only for the purpose of this work.

8.2 questions

1. What is your gender?

Although this questionnaire is totally anonymous, I found it important to identify the gender of the respondents because one gender might be more prone to watching sport. Another factor is definitely gender diversity, which increases the objectivity of the survey and its accuracy. The results show that the vast majority of respondents are men (56 respondents, 88.9%), and only 7 of them identify as women (11.1%). This suggests that men are more likely to watch sports than women. However, the results of this survey are, in my opinion, slightly distorted. This is mainly because this questionnaire was shared in groups occupied mainly by men. I believe that with the increasing number of respondents, the percentage of women watching sports would increase, too (see Figure2).

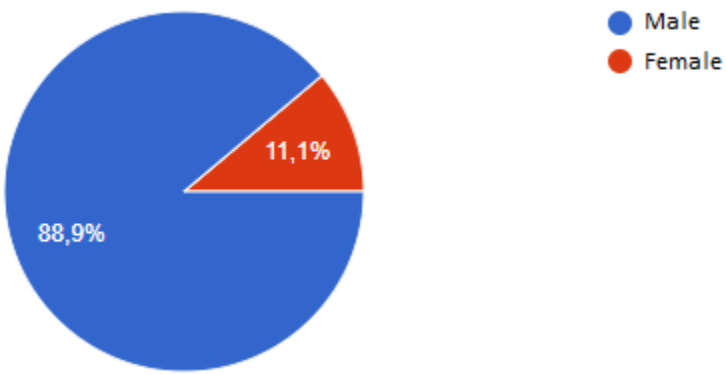

Figure 2: Gender diversity

2. What is your age?

The second question deals with the age of respondents. This question could be crucial, as participants' knowledge and experience may vary with age. More than half respondent said they are 22-25 years old (38 respondents, 60.3%). The second largest group is 26 years old and above (16 participants, 25.4%). The third largest group is the group from 18-21 years (8 respondents, 12.7%), and the least represented group is 1 (1.6%) 15-17 years old (see Figure 3).

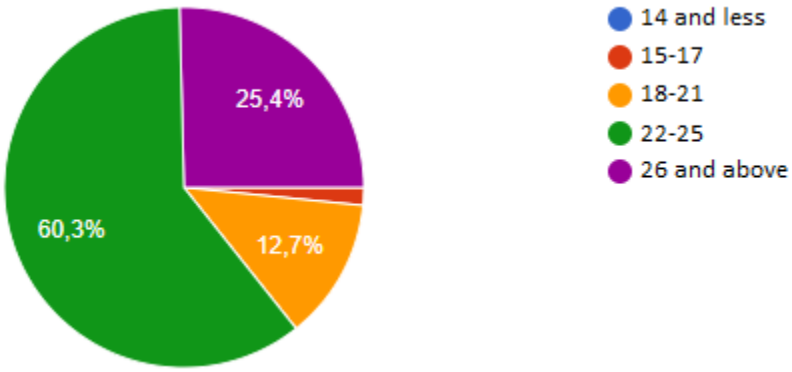

Figure 3: Different age groups

3. Are you a sports fan?

This is a rather reassuring question because this questionnaire was designed for sports fans. If a questionnaire was filled in by someone without knowledge of the sport, the results could be very distorted, and the survey would lose on accuracy and objectivity. As we can see in Figure 4, a total of 46 (73%) respondents identify themselves as sports fans, another 15 (23.8%) participants also feel to be sports fans to some extent. Only a very small proportion of respondents 2 (3.2%) are not feeling like sports fans. Therefore, the objectivity and quality of the data collected should be sufficient.

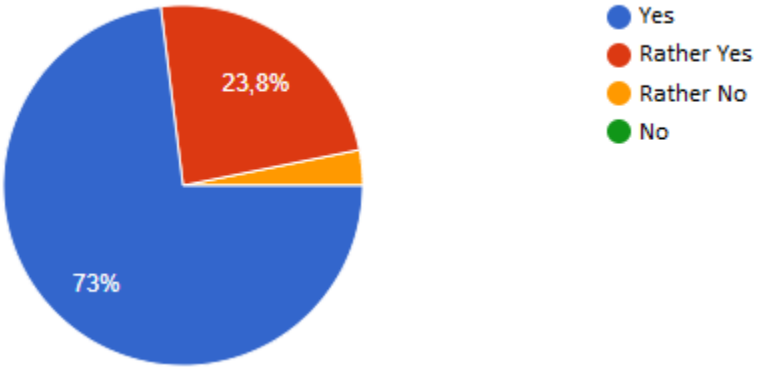

Figure 4: Are you a sports fan?

4. Which sports do you actively follow?

In this case, respondents were asked which sports they actively follow. Respondents had a choice of several options, could choose multiple responses at once, and could also specify their own answers. As we can see, out of a total of 63 respondents, the vast majority of 53 respondents (84.1%) are interested in football, 39 (61.9%) of them watch hockey, 26 of them watch basketball, and a total of 23 respondents (36.5%) likes American football. As the participants had the opportunity to show their own answers, a total of 5 participants (7.9%) also watch another sport. These sports included speed skating, downhill, mixed martial arts and biathlon. Obviously, traditional sports are particularly popular, which is a good thing for this survey since instant replay technology is actively involved in these sports. Therefore, respondents should have a considerable amount of information about the functionality of these technologies (see Figure 5).

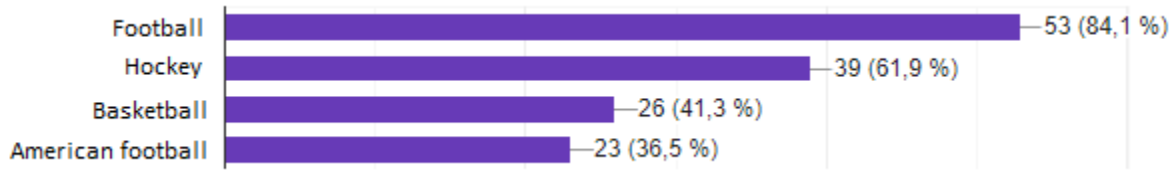

Figure 5: Sports sorted by popularity

5. Are you aware of the basic rules for using instant replay?

In this question, participants are asked about the rules associated with instant replay. As can be seen, (see Figure 6) the overwhelming majority of respondents (59 participants, 93.6%) are, to some extent, familiar with the rules associated with the use of instant replay. And so, it should not be a problem for them to answer the extension questions

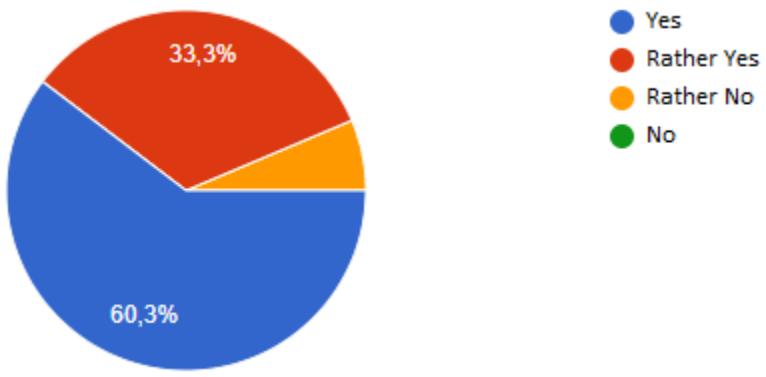

Figure 6: Are you aware of the basic rules for using instant replay?

6. If so, where did you get to this information?

I found it important to specify from which sources the respondents heard about this information. Specifying the best sources can then be used to disseminate information regarding instant replay to the general public better. Such dissemination of information could in the future eliminate some of the problems of instant replay technology, for example, confusing rules. Respondents had the opportunity to select multiple responses and also had the opportunity to specify their own answers. In this case, 51 (81%) respondents gained information regarding rules of instant replay from the Internet. Further, the second-best source (television) comprised of 47 participants (74.6%). It is no coincidence that these two sources are the most popular, as these are the places where people spend a considerable amount of time. Significantly less popular sources of information were news and friends both consisted of 13 respondents (20.6%). Two respondents (3.2%) specified their own answers and said they had learned about the rules during the game (see Figure 7).

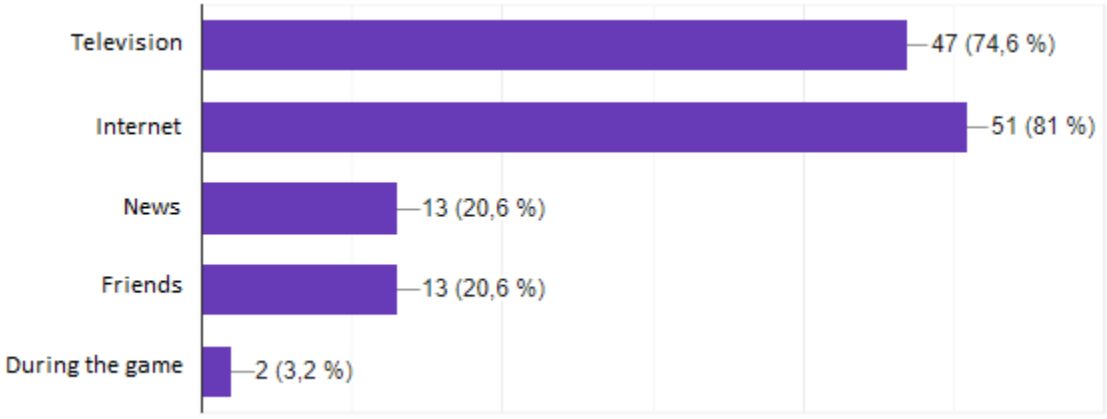

Figure 7: sources of information about instant replay sorted by popularity

7. Are these rules sufficiently specified?

This is a follow-up question in order to find out whether these rules are sufficiently specified according to respondents. As we already know, some rules can be confusing and can even lead to riots in the auditorium (see Chapter 2). The results of this question are rather surprising to me, as the vast majority of respondents believe that the rules are specified rather sufficiently. A total of 23 (36.5%) respondents believe that the rules are sufficiently specified, while the biggest group of 30 participants (47.6%) also believe that the rules are rather sufficiently specified, but only to some extent (see Figure 8).

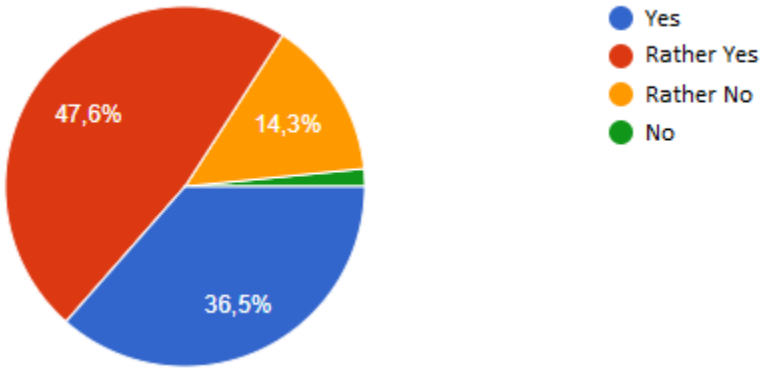

Figure 8: Are these rules sufficiently specified?

8. At what level are the technologies used by instant replay according to you?

The technologies used for the instant replay are certainly at a much higher level than ever before, whether it is UHD cameras, tracking systems, or else. The question is, are these technologies advanced enough to allow video judges to be comfortable enough to assess unclear situations? For this question, I used Likert-type of scale, with five options where number 1 indicates insufficiency and number five indicates sufficiency. Nineteen respondents (30.2%) believe that technologies used by instant replay are in fact on a very good level, while the biggest group of 31 participants (49.2%) also believe that these technologies are sufficient. The third biggest group of 8 participants (12.7%) remains neutral, and only an insignificant number of respondents holds a sceptical point of view over these technologies. Thus, the survey shows that technologies are of a sufficiently high standard to provide referees with quality conditions for the assessment of unclear situations (see Figure 9).

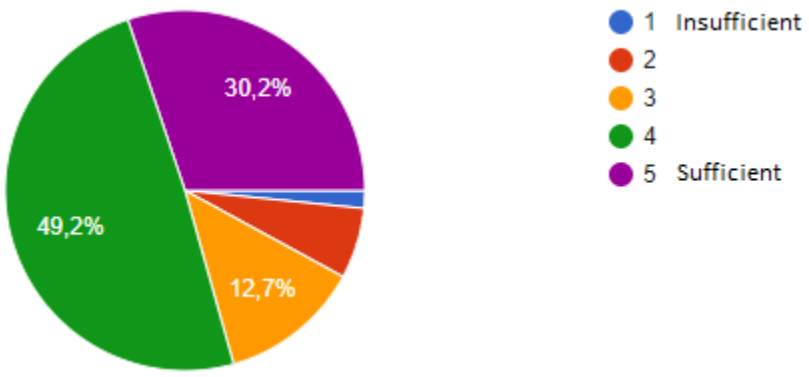

Figure 9: The level of technologies used by instant replay

9. What do you think is the main purpose of introducing an instant replay?

The main purpose of instant replay is obviously the elimination of obvious errors that could affect the outcome of the match; all 63 participants (100%) agreed. Respondents had the opportunity to select multiple answers or specify their own opinions. A total of 8 respondents (12.7%) believe that these technologies serve to some extent to monitor the behaviour of fans in the auditorium and to identify rioters. Unfortunately, none of the respondents used the opportunity to contribute their opinion.

10. What do you think is the biggest flaw of instant replay?

Obviously, instant replay brings some negatives as well (see Chapter 2). The aim of this question is to find out which negatives are the most serious. Respondents could choose multiple answers or specify their own opinions. The vast majority of respondents (52 respondents, 82.5%) are concerned about delaying the game, and a total of 44 respondents (69.8%) believe that initial costs are also very serious difficulty as minor leagues and less wealthy countries cannot afford these technologies. While only a small number of participants (15.9%) believe that confusing rules is a serious difficulty regarding instant replay (see Figure 10).

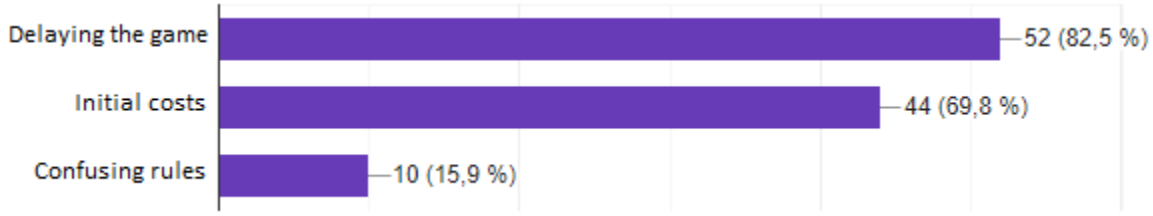

Figure 10: The evaluation of the biggest flaws of instant replay

11. To what extent does instant replay delay the game?

As we can see from the results of the tenth question, delaying the game appears to be a major problem of instant replay. For this reason, the participants were asked to what extent does the instant replay delay the game. For this question, I used Likert-type of scale, with five options where number 1 indicates an insignificant extent and number five indicates an enormous extent. As we can see from the graph (see Figure 11), most respondents held a rather neutral position, and only a few individuals chose one of the highs. Despite the fact that 82.5% of respondents chose delaying the game as a serious difficulty, only five respondents (7.9%) believe these are enormous delays. The results show that respondents are aware of delays, but they do not find them excessively long.

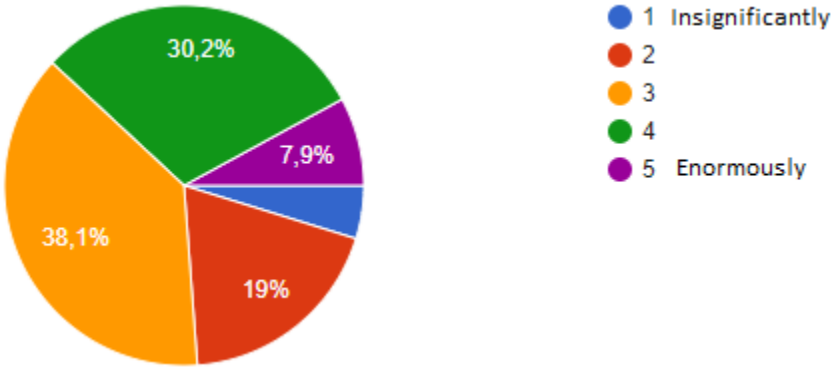

Figure 11: To what extent does instant replay delay the game?

12. To what extent do you think the instant replay improves the game's objectivity?

As we can see from the results of the ninth question, improving the objectivity of matches is the main purpose of instant replay, as all 63 respondents agreed. For this reason, the participants were asked to determine the extent to which instant replay improves the game's objectivity.

As we see from the graph (see Figure 12), it is obvious that most respondents agree to some extent that instant replay rather improves the objectivity of matches. Twenty-one of them (33.3%) believe that improvement is enormous. While the largest group of 27 respondents (42.9%) believe that these technologies, in fact, improve objectivity, but only to a certain extent. Ten respondents (15.9%) remain neutral, and only a small number of participants remain sceptical.

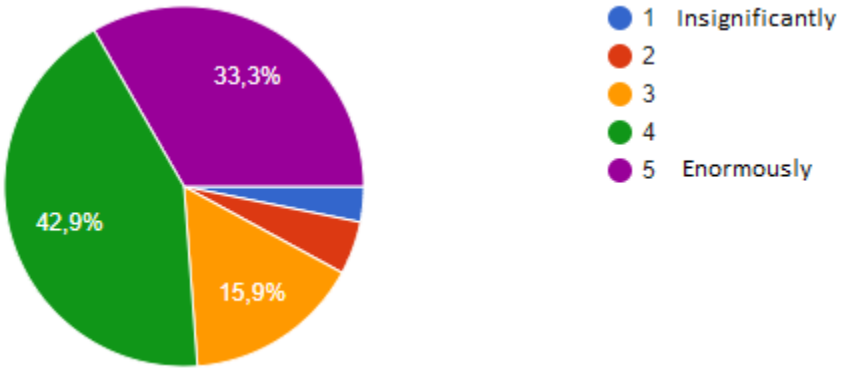

Figure 12: The evaluation of objectivity's improvement

13. to what extent does the negative human element disappear from the game due to instant replay?

Despite the fact that instant replay helps to reduce bad decisions made by referees, a negative human element in matches remains, as instant replay technologies can only be used in specific situations, other situations that differ from them still remain in the competence of the referee on the field. Participants were therefore asked to determine the extent to which the negative human element disappears from the game due to instant replay. It is clearly visible that the vast majority of people remain rather neutral as the biggest group (26 participants, 41.3%) remains completely neutral. And given the fact that none of the non-neutral sides really exceeds the other, it is safe to say that according to respondents the extent of the negative human element in games remains the same (see Figure 13).

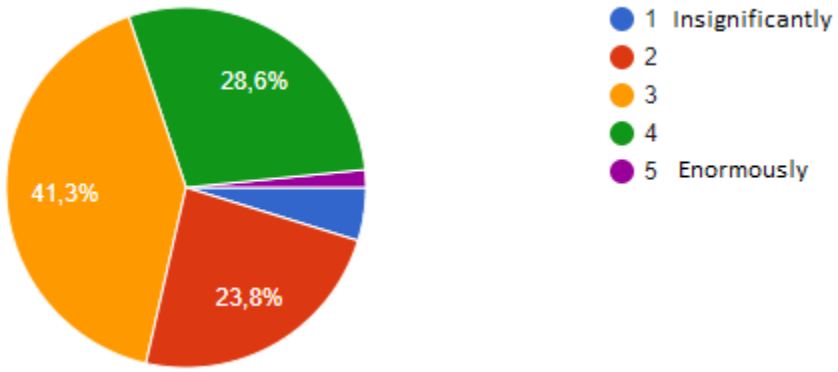

Figure 13: The evaluation of departure of the negative human element from the game

14. To what extent do you think the breaks caused by the instant replay affect the pace of the players/game

The breaks caused by instant replay allow players to regain energy, catch a breath and might cause the team that had the power of momentum to cool down. All these aspects damage the game to a certain extent. For this reason, the participants were asked to what extent the breaks caused by instant replay affect the pace of players/game. A total of 16 respondents (25.4%) believe that these breaks have enormous effect on the pace of the game/players, 24 of them (38.1%) agree to a certain extent, and 16 participants (25.4%) remain rather neutral and only a small number of respondents do not believe that these breaks have any effect on the pace of the game/players. This problem is

the first in which respondents expressed rather negatively. Which means most likely that this problem bothers them the most (see Figure 14).

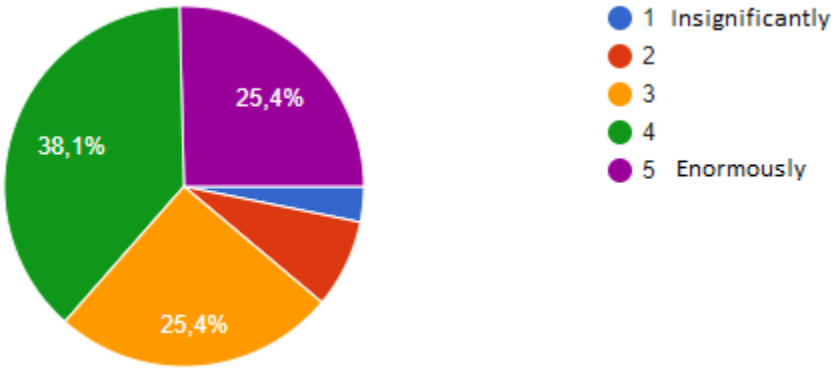

Figure 14: Evaluation of breaks and their effect on the pace of the game/players

15. Do you think referees should worry about their professional future because of new technologies?

As we know, over the past 50 years, instant replay technologies have made a huge step forward, but how much will these technologies move in the next 10 or 20 years? Is it possible that the human element will disappear completely from the field? According to most respondents, the human element will remain on the field even in the future, but there are some (5 respondents, 7.9%) who believe that the referees will be completely replaced (see Figure 15).

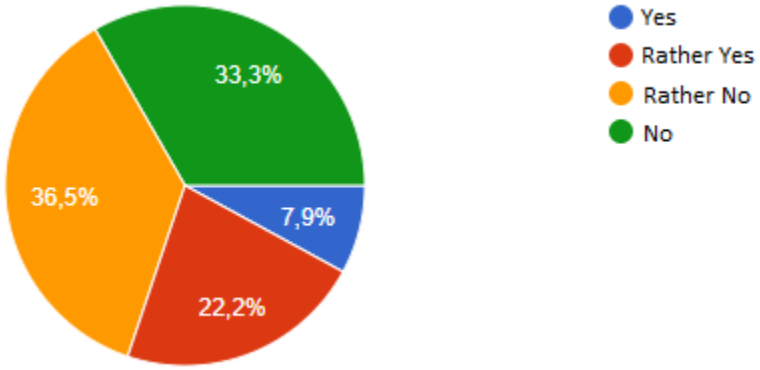

Figure 15: Should referees worry about their professional future because of new technologies?

16. Do you think these technologies are beneficial to the sport?

Now we know all the pros and cons, and it is necessary to decide whether the technology associated with instant replay is beneficial to the sport or rather harmful. The overwhelming majority (45 participants, 71.4%) of respondents believe that these technologies are very beneficial to the sports and another 14 respondents (22.2%) tend to agree to a certain extent. I believe that this survey confirmed that, despite a significant number of shortcomings, instant replay is an integral part of the sport and is indeed very beneficial (see Figure 16.)

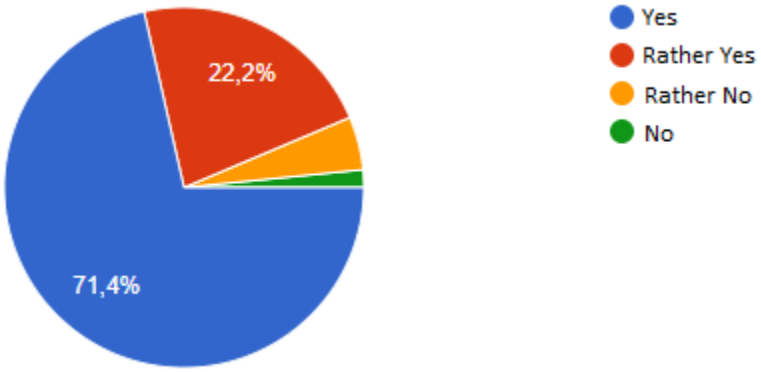

Figure 16: Are these technologies beneficial to the sport?

17. Do you agree with the use of the instant replay in the future?

After the results of the 16th question, it is certainly no surprise that the vast majority of respondents (93.6%) tend to agree with the use of instant replay in the future.

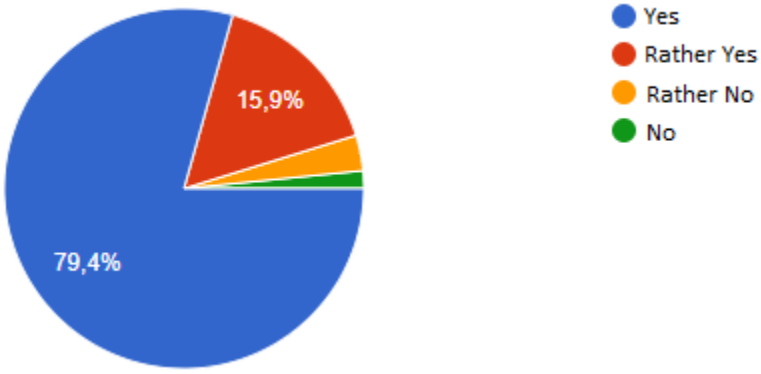

Figure 17: Do you agree with the use of instant replay in the future?

9 Conclusion

The theoretical part of this thesis deals with reasons for the demand of these technologies, where both the main negatives and the clear advantages are described. It describes technological officiating aids used in football, their usage on past World championship in Russia and specific rules that had to be adopted. Further, it describes operation centres used in the NBA and NFL with a brief explanation of their functionality. The last part of the theoretical part deals with historical moments that helped to change the history of the sport forever, due to their controversial process.

The empirical part of this thesis deals with the analysis of technological officiating aids in game sports. The analysis was carried out in the form of a questionnaire. A total of 63 anonymous participants contributed to this survey with their answers. The result of this survey showed that despite all the negatives, 93.6% of respondents believe that these technologies are beneficial to the sport, and 95.3% of the respondents agree with its usage in the future.

Regarding the technological officiating aids used in football. Goal line technology has significantly improved the game of football without any notable downside apart from initial costs. GLT technology is precise, reliable, swift and does not affect a game in any negative way. On the other hand, the VAR has a significant number of drawbacks. It delays the game, occasionally affects the pace of the game and requires large investments. Despite all these negatives, VAR ensures a much fairer game, which is much more valuable.

The instant replay system used by the NBA has been functioning for several years. Even though that the average review time has significantly decreased I believe that the amount of reviews per game is considerable. Especially in the last two minutes of the fourth quarter when the amount of reviewable plays significantly increases. Nevertheless, I still believe that instant replay made the NBA better.

According to me, the instant replay system used by the NFL is the best out of three sports I have covered. NFL averages only 1.3 reviews per game with the length of the review being tolerable due to the nature of the game. I also appreciate the possibility of coaches' challenge.

In conclusion, I believe that all these technological officiating aids made their respective sports better.

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11 List of figures:

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13 Appendix:

The questionnaire

Hello,

I would like to ask you to fill in the questionnaire, which is part of my bachelor thesis on "Instant replay technologies and its Influence on Game Sports."

My name is Roman Nguyen, and this survey serves as an empirical part of my bachelor's thesis. The purpose of this questionnaire is to determine whether instant replay technologies helped or made things worse.

The survey is completely anonymous

Many thanks for your time and willingness.

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1) What is your gender?
   - □ Male
   - □ Female

2) What is your age?
   - □ 14 and less
   - □ 15-17
   - □ 18-21
   - □ 22-25
   - □ 26 and above

3) Are you a sports fan?
   - □ Yes
   - □ Rather Yes
   - □ Rather No
   - □ No

4) Which sports do you actively follow?

- ☐ Football
- ☐ Hockey
- ☐ Basketball
- ☐ American football
- ☐ Specify_____

5) Are you aware of the basic rules for using instant replay?

- ☐ Yes
- ☐ Rather Yes
- ☐ Rather No
- ☐ No

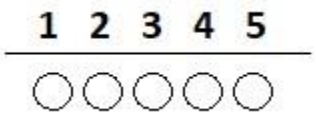
6) If so, where did you get to this information?

- ☐ TV
- ☐ Internet
- ☐ News
- ☐ Friends
- ☐ Specify_____

7) Are these rules sufficiently specified?

- ☐ Yes
- ☐ Rather Yes
- ☐ Rather No
- ☐ No

8) At what level are the technologies used by instant replay according to you



Insufficient Sufficient

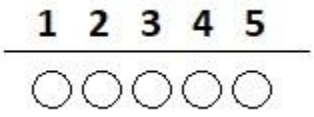
9) What do you think is the main purpose of introducing an instant replay?

- ☐ increase accuracy and make sure that obvious errors are corrected
- ☐ slowing the game down
- ☐ Monitoring fan behaviour
- ☐ Specify_____

10) What do you think is the biggest flaw of instant replay?

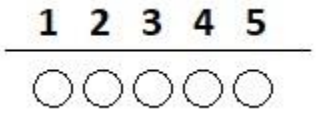
- ☐ Delaying the game
- ☐ Initial costs
- ☐ Confusing rules
- ☐ Specify_____

11) To what extent does instant replay delay the game?



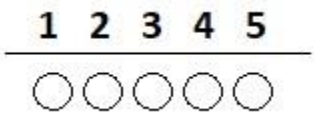
Insignificantly Enormously

12) To what extent do you think the instant replay improves the game's objectivity?



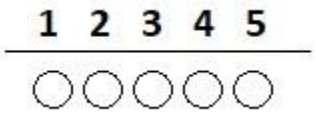
Insignificantly Enormously

13) To what extent does the negative human element disappear from the game due to instant replay?



Insignificantly Enormously

14) To what extent do you think the breaks caused by the instant replay affect the pace of the players/game



Insignificantly Enormously

15) Do you think referees should worry about their professional future because of new technologies?

- Yes
- Rather Yes
- Rather No
- No

16) Do you think these technologies are beneficial to the sport?

- Yes
- Rather Yes
- Rather No
- No

17) Do you agree with the use of the instant replay in the future?

- Yes
- Rather Yes
- Rather No
- No